



Collaborative Product Development in an R&D Environment

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Abstract

Collaborative Product Development (CPD) and Supply Chain Management (SCM) can have significant implications for the development of aerospace technologies and systems. Most studies on the application of CPD and SCM have been performed in manufacturing, information technology, or telecommunications environments. Research into the applicability and benefits of CPD in an R&D, and/or government environment is limited. This paper presents research conducted at the NASA Glenn Research Center investigating the applicability of CPD with SCM in an R&D organization. The study concentrates on the management and implementation of space technology research activities. Results and recommendations are based on a number of interviews and mail-in surveys.

1.0 Introduction

Federal research laboratories are implementing new ways for the management of their Research & Development (R&D) activities. As in other R&D organizations, NASA scientists must show that the research and resultant technologies that they are engaged in will benefit the Agency and the Nation by enhancing or enabling current or planned missions. There are “new changes, challenges, and opportunities for NASA ... some of these require a transformation in the way we plan and operate programs” [1]. This situation is very similar to that documented for many other organizations involved in R&D activities, where researchers are being asked to be relevant, to be more application-oriented, and to consider themselves key partners in the strategic management of the business, bringing benefits to the bottom line [2,3,4,5]. R&D is being asked to meet the same challenges as the rest of the organization, namely: 1) reduce time to market; 2) reduce cost; 3) increase focus on customer needs; 4) increase quality and reliability; and, 5) increase value [2,6,7]. These must be accomplished while using congruent project management methods and system engineering processes and tools throughout the enterprise and while bringing in external resources and expertise.

As a result of advances in computer technology and the Internet, a new paradigm, called *collaborative engineering*, or *collaborative product development (CPD)* has emerged. This new paradigm can have significant implications for product development and especially for the development of complex aerospace technologies and systems that are developed by the NASA and its partners. This new, collaborative way of developing technologies and aerospace systems has changed the ways aerospace systems are designed, produced, operated, maintained, and disposed of. By combining the strength, expertise and know-how of the best diverse, geographically dispersed technical teams, better mission scenarios, designs, and the corresponding technologies can be developed in less time. The potential benefits of these collaborative, distributed environments for product development and scientific research have led government agencies to start several CPD efforts [8-11].

The Collaborative Enterprise, or CPD, is the application of team-collaboration practices to an organization's total product development efforts. It builds upon the systems engineering [12], project/program management foundations of primarily in-house cross-functional product development teams introduced by concurrent engineering [13]. CPD is concerned with creating the necessary environments for effective, free flowing information and ad-hoc collaboration among peers involved in these mostly external knowledge worker partnerships [14]. Supply Chain Management (SCM) has emerged as a key component of successful CPD implementations [15]. The implementation of CPD and SCM coupled with developments in technology and globalization have resulted in the creation of virtual

teams, which allow managers to assemble the best knowledge worker talent they can find from wherever they can find it [16].

Research into the applicability and benefits of CPD into a low/no production, service, research and development, and/or government environment is limited. Since CPD is an “extension” or evolution of concurrent engineering (CE), it can be expected that many of the benefits attained by CE practitioners would be achieved with a CPD environment. These benefits of CE have been widely documented [17-19]. The research on CPD has documented benefits and challenges that are similar to those for CE, as well as some unique ones due to CPD’s unique characteristics [20-26]. Others have documented the very important role that “suppliers” and SCM play in these collaborative endeavors [15, 27-30]. Whether or not these potential benefits, barriers, and implementation models for CPD are applicable to an environment such as a federal research laboratory has not been studied in depth. Furthermore, the role of federal research centers as suppliers of technology and expertise presents a unique opportunity to explore this new collaboration paradigm while incorporating aspects of SCM.

This particular research explored the application and impacts of CPD and SCM in a high technology R&D organization (NASA Glenn Research Center), and whether this organization can be considered a supplier of technology or competencies within a larger supply chain. The NASA Glenn Research Center (GRC) is NASA’s premier center for aerospace research and development in the areas of space power, electric propulsion, and communications. With these roles, GRC leads or supports a wide variety of programs and projects, primarily as a provider of technology and other expertise. Because of the diverse nature of its R&D projects envelope, GRC provides an excellent model for this type of research.

2.0 Research Methodology

The research was carried out in two phases via a combination of interviews and a mail-in survey to personnel involved in the implementation of space technology development activities. An extensive literature review helped develop the interview protocol that was used to interview six managers. The interviews were analyzed via a detailed content analysis process [31,32]. Preliminary findings from these interviews have already been reported [33]. These results were also used to refine the mail-in survey, which was sent to 222 potential respondents, of which 115 replied.

The survey results were analyzed using accepted methodology for organizational management research [34,35]. Demographic data gathered included information on the respondents’ functional responsibilities, experience level, and organizational affiliation. Parametric analyses were also conducted to look for any significant differences among the various demographic groupings.

The research investigated the following factors of the organization’s CPD implementation and how they might influence CPD success:

- Organizational readiness
- The business environment or context in which the organization operates
- Supply chain management factors
- Management support
- Knowledge management and information technology
- Customer focus

This paper discusses the results of the research as it pertains to the business environment in which the organization is operating and how it affects CPD implementation.

3.0 Collaborative Product Development

In the current business environment, organizations have to cooperate more with their suppliers, their customers, and other relevant parties [20-30]. As defined previously, CPD is the application of team-collaboration practices to an organization’s product development efforts. It builds upon the nature of cross-functional product development teams introduced by concurrent engineering (CE).

Willaert et al. [24] defined CPD as an extension or evolution of CE. In their view, CE did not address control over life-cycle cost, product quality, and time to market. In addition, the enabling role of information technology (IT) was not directly specified, and more important for this discussion, supplier involvement was not addressed, even though supplier input is vital to achieving optimized designs [15,21,27-30]. Willaert et al. determined that decision-making should proceed **collaboratively** and defined CPD as: *a systematic approach to control life cycle cost, product quality and time to market during product development by concurrently developing products and their related processes with response to customer expectations, where decision making ensures input and evaluation by all life-cycle disciplines, including suppliers, and information technology is applied to support information exchange where necessary*. From this definition, it is clear that CPD encompasses concurrency, attention to the life-cycle, suppliers, and information technology, all while maintaining a customer-focused environment.

Littler et al [20] summarized previous research on collaboration, and state that collaboration is an evolutionary process, dependent on inputs, outputs, management influences, and environmental influences. They define these factors as:

- Collaboration inputs: brought to the start of the collaboration by the parties involved and are ingredients which might affect the collaboration process and its eventual outcome
- Management influences: factors relating to ongoing collaboration management which are likely to influence the eventual collaboration outcome
- Environmental influences: factors which are not under the direct control of management but which may have significant impact on the outcome
- Collaboration outcomes: need for a broader view of collaboration outcomes besides “success” or “failure”

Jassawalla and Sashital [36] examined collaboration in new product development (NPD) in high-technology organizations. They define collaboration as more complex than mere cooperation, with a higher intensity of cross-functional linkages, a sense of an equal stake in outcomes, no hidden agendas, and a willingness by the participants to understand and accept differences while remaining focused on the common goals and objectives. Collaboration also involves synergy. Their resulting framework suggests, among other things, that high levels of integration do not necessarily equate to high levels of collaboration – the characteristics of the organization and the participants also affect the level of collaboration. For example, achieving a high level of collaboration depends on participants who are open to change, willing to cooperate, and with a high level of trust.

Daniel, et al [26] developed a model to assess the value of collaborative R&D programs and found that successful industry/university consortia leveraged four core process relationships:

- The creation of research capacity yielding advances in process and product knowledge.
- Technology transfer behaviors within the participants’ organizations.
- Participant satisfaction with the outcomes
- Continuity of industry sponsor support, i.e., commitment to the collaboration.

Their research suggests that customer satisfaction plays a central role in the formation of commitment to collaborations among organizations.

Another aspect of this research was to investigate the issues around SCM, in the context of technology and mission development for particular missions or applications. It is proposed that the R&D organization can act as a supplier of competencies or specific technologies. Hurmelinna et al. [37] describe how an innovative environment in supplier relations for specific R&D activities is crucial for new product development. Accordingly, supplier involvement in R&D requires much joint effort, good processes, smooth communication methods, technological competency, and trustful relationships.

The benefits of supplier integration in the new product development process (NPD) have been widely investigated. These benefits can be: reduced development time and cost, access to new technologies or capabilities, and increased quality. Collaborative SCM/NPD goes beyond mere exchanging and integrating information between suppliers and their customers, and involves tactical decision making among the partners in the areas of collaborative planning, forecasting, distribution, and product design. It also involves strategic joint decision making about partnerships and network design. It calls for commitment and trust over an extended period of time and includes the sharing of information, risks, and rewards [27-30,37-40]. Chen [41] also noted that as organizations learn about new business processes, they will recognize that behavior changes needed to support new ways of doing business are the most

critical to acquire these new competencies. Chen and Small [42] also point out that closer working relationships among all functions of the organization are required if the innovation objectives are to be achieved.

4.0 Findings on Business Environment Implications for CPD

This factor measured how conducive to CPD is the business environment in which the organization operates. It addressed issues or policies that are driving the organization, control of resources, organizational issues, the role of CPD/SCM in the organization, standing of the organization, and how any changes in the business climate have impacted the organization.

The parametric tests indicated that the current business environment is conducive to or is a driver for increasing CPD activities. The content analysis of the interviews describe an organization that, in general, is moving towards increasing collaborative activities as a way to remain relevant and competitive in this environment.

The type of work that the organization is involved in requires CPD. Because of the types of technologies and research that they carry out, they no longer have all the competencies and other resources (personnel, facilities, funding) necessary to accomplish all objectives. The R&D activities have become multidisciplinary, requiring participation by different organizations. The survey respondents also recognized the complexity of the R&D and technology development activities they are involved in, which require a constant assessment of the organization's and of its potential partner's capabilities.

The organization also has new roles, which was reflected in the survey. These new roles are primarily new programs or projects, but they also represent new ways of doing business. Collaboration requires a set of skills and competencies that were not needed previously. These include the capabilities (and willingness) to exchange and integrate information between partners, tactical decision-making among the partners, joint advocacy and proposal development, CPD, inter-organizational management skills, and others. It also requires strategic joint decision making about partnerships and network design. At an individual and organizational level, it will also require an openness to change and a need to be flexible and adaptable to different processes.

Regarding organizational capabilities, it was recognized that, this being a knowledge organization, its most important resources are personnel and unique facilities. The organization must have the necessary competencies that make it a worthy partner, and there is a view that the testing facilities are one of the greatest assets and competitive advantages that they can offer in any kind of collaborative activity. Respondents also indicated that the organization is recognized for its technical expertise. Of extreme importance is that the R&D organization must continue to be recognized as "experts" or possessing some unique capabilities and/or competencies. This is important because there will be instances when the only resources that the organization can offer to a potential partner are these unique capabilities.

There are some potential barriers to implementing CPD activities. One of them is the inherent instability of the government funding cycle. Managers stated that this was one of the main issues they had to deal with, since this instability affected their planning and ability to deliver on schedule. Respondents were again strong in indicating that they also see this as a major issue. The other indicator dealt with issues related to the matrix organization. Among the managers, most saw the matrix organization in a positive light—because of it they have to collaborate more, have developed partnerships, understand what capabilities exist in other organizations. Survey respondents, however, agreed very strongly with the statement that it causes "confusion and power struggles".

Another important issue is the ability to communicate efficiently. One of the managers said that one of the first challenges is just to "have the right information up front". Members need to "develop relationships", which would be enabled by adequate communication tools and modes. However, sometimes government regulations can impeded the very open modes of communication that are needed to develop the trust. Procurement regulations also limit the flexibility of federal laboratories.

Lastly, with the increased emphasis on competition for government funding, it may be driving the organization away from its "smart buyer" position and into adversarial relationships with some of its current partners.

5.0 Conclusions

The current business environment for R&D organizations is a driver for increasing collaboration within organizations and also with external organizations. This trend is being helped by continued developments in information technologies and the evolution of research activities into multi-disciplinary activities requiring resources and expertise that are not resident in just one organization. For government R&D organizations, these trends are also real, but they can be negatively impacted by the instabilities in the budget process and by certain regulations that may hamper the expeditiousness of implementing these collaborative activities. Finally, the government laboratories role as a “smart-buyer” may be impacted by the move towards increased competition for funding.

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